December 14, 2022

Charles E. Zielinski
State of New Jersey
Department of Environmental Protection
Site Remediation Program
Bureau of Case Management
Mail Code 401-05F
PO Box 420
Trenton, NJ 08625-0420

Re: Proposed Alternative Ground Water Quality Criteria for the Class III-B Area
Bayway Refinery Complex

Dear Mr. Zielinski,

As a subsequent action to our October 2021 proposal Surface Water Quality Criteria to the New Jersey Department of Environmental Protection (NJDEP), Kleinfelder has evaluated ground water flow, surface water flow, and surface water quality criteria, to propose Alternative Ground Water Quality Criteria for the Class III-B Area at the Bayway Refinery Complex (BRC). These criteria are meant to be protective against chronic ecological impacts to saline surface waters under a potential future condition of a non-operating refinery, and without the current ground water management system(s) operation. It is anticipated that these criteria may also be used to monitor ground water conditions in the event that changes in ground water control system operations result in potential flow of ground water through existing gaps in the various containment structures.

Hydrogeology

The BRC is within the glaciated portion of the Piedmont physiographic province, which is underlain by igneous and sedimentary rocks. Site bedrock exists below unconsolidated materials consisting of the following units: fill, alluvial deposits, meadow-mat, and glacial till. The areas of meadow mat are consistent with wetlands which are depicted on maps as recently as 1894. The total thickness of unconsolidated materials range from less than five (5) feet to more than 50 feet (Geraghty & Miller, Inc., 1993) (TRC Raviv, 2004) (TRC, 2016). Bedrock elevations are highest in the north-central portion of Unit A and lowest in the Waterfront Area, the Sludge Lagoons, and the central region of the Tremley Tankfield.

© 2022 Kleinfelder

Class III-B Area

A Class III-B ground water area (Class III-B Area) was defined within overburden materials at the Bayway Refinery, Linden, New Jersey in 2000. Subsequently, the NJDEP approved both the Class III-B Area and proposed Class III-B Ground Water Quality Criteria for lead, benzene, methyl tert-butyl ether, phenol, naphthalene, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, 1,2-dichloroethane, 1,2-dichloropropane, 2-butanone (methyl ethyl ketone), and acetone (Dan Raviv Associates, Inc., 2000). Since defined in 2000, the determination of the Class III-B Ground Water Area for the overburden aquifer has not changed. In order to develop Class III-B Ground Water Quality Criteria protective of chronic exposures by saline biota for additional compounds of concern (COCs), Kleinfelder has prepared updated ground water to surface water flow modeling and ExxonMobil has previously (Kleinfelder, Inc. , 2021) proposed to the NJDEP to utilize surface water screening values from the United States Environmental Protection Agency (US EPA) Region 4 Screening Values (US EPA, 2018), if existing NJDEP Surface Water Quality Standards were not available. The proposed criteria are intended to be applicable for a condition wherein ground water flow to the receiving surface water bodies is not controlled. As such, the proposed criteria can also be used to demonstrate that no adverse effect to the surface water body is predicted in instances where ground water flow to the surface water bodies is not controlled, for instance if hydraulic containment is temporarily lost due to a mechanical malfunction.

The Class III-B area extends approximately 4,300 feet inland from the Arthur Kill and encompasses approximately 330 acres. The Class III-B area includes the entirety of Investigative Area of Concern (IAOCs) C1, C2, C3, C4, C5 (the Waterfront Area), B1, B2, and B3 (B-series), as well as portions of A18 (Pitch), A17 (Caverns), A16 (Cogen), A7a (Eastside Chemical Plant), A7b (Westside Chemical Plant), and E2, E3, and E4 (Landfills). The Class III-B area is located adjacent to the saline waters of the Arthur Kill and lower reaches of Morses Creek and coincides with salt water tidal creeks and marshes shown in the 1893 and 1894 historical maps and the 1939 photograph (Figures 7 through 10 of (Dan Raviv Associates, Inc., 2000). The Morses Creek channel (a historical tidal creek) meanders from the southwestern corner to the northeastern corner of the Class III-B area. The surface water flow in Morses Creek is to the northeast. Tidal impacts are not generally observed in Morses Creek, due to the installation of No. 1 Dam. However, during severe weather (tidal surges), impacts can be observed up to No. 2 Dam.

Regulatory Framework

Alternative, site-specific Ground Water Quality Criteria have been calculated for Class III-B ground water areas at the refinery. This section presents the bases that were used in the selection of alternative numeric criteria. The Class III-B Ground Water Quality Criteria were determined on an area-by-area basis, in response to case-by-case needs, in the context of applicable regulatory programs, and based on the requirements of the GWQS rule, N.J.A.C. 7:9-6.7, as follows:

1. As per N.J.A.C. 7:9-6.7(f) 1, the criteria are no more stringent than necessary to ensure that there will be no impairment of existing uses of ground water;
2. As per N.J.A.C. 7:9-6.7(f) 2, the criteria are no more stringent than necessary to ensure that there will be no resulting violation of surface water quality standards;

© 2022 Kleinfelder

3. As per N.J.A.C. 7:9-6.7(l) 3, the criteria are no more stringent than necessary to ensure that there will be no release of pollutants to the ground surface, structures or air in concentrations that pose a threat to human health; and
4. As per N.J.A.C. 7:9-6.7(f) 4, the criteria are no more stringent than necessary to ensure that there will be no violation of constituent standards for downgradient classification areas to which there is a significant potential for migration of ground water pollutants.

All but one small portion of the Class III-B area discharges directly to surface water. Ground water in this small portion of the Class III-B area flows south for approximately 200 to 1,400 feet before discharging to the tidal, saline waters of Piles Creek. Currently, downgradient ground water is not used for potable or other uses. Therefore, alternative criteria will not result in impairment of existing uses of downgradient ground water.

The alternative, site-specific Class III-B Ground Water Quality Criteria proposed in this report ensure that there will be no impairment of existing uses of ground water pursuant to N.J.A.C. 7:9-6.7(f) 1.

Ground water in the Class III-B area discharges to the surface waters of Morses Creek, the Arthur Kill, an unnamed tributary to Morses Creek and Piles Creek. The New Jersey Surface Water Quality Standards ("SWQS") rule, N.J.A.C. 7:9B et seq., outlines the state's policy for antidegradation of surface water, and contains promulgated numeric surface water quality criteria.

The SWQS rule, N.J.A.C. 7:9B-1.15(e) - Table 3, classifies surface waters of the Passaic, Hackensack and New York Harbor Complex Basin. In the vicinity of the refinery, the Arthur Kill is classified as "SE2." An SE classification is applied to saline waters of estuaries, or waters having salinities generally greater than 3.5 parts per thousand at mean high tide. Morses Creek is classified as "FW2-NT/SE3." An FW2-NT/SE3 classification applies to a waterway with a salt water/freshwater interface. For Morses Creek, the point of demarcation between the fresh and saline waters (that point where the salinity reaches 3.5 parts per thousand at mean high tide) has been determined by salinity measurements to be at No. 2 Dam. In the fresh portions above No. 2 Dam (i.e., the Reservoirs), Morses Creek is classified as FW2-NT; in the saline portions below No. 2 Dam (i.e., in the vicinity of the Class III-B ground water area), Morses Creek is classified as "SE3". Piles Creek is classified as "SE3."

Numeric surface water quality criteria for SE waters have been promulgated by the Department at N.J.A.C. 7:9B-1.14(c) and include: aquatic life protection criteria (acute and chronic); effect-based human health criteria (carcinogenic and non-carcinogenic); and organoleptic criteria. Pursuant to N.J.A.C. 7:9B-1.5(c) 2, surface water quality criteria are expected to be maintained during periods when non-tidal or small tidal flows are at or greater than the appropriate design flow.

As approved by the NJDEP, US EPA Region 4 Screening Values will be used for COCs without established NJDEP Surface Water Quality Standards. Additionally, since the surface water surrounding the BRC are not used for human recreational activities, only the aquatic standards will apply.

© 2022 Kleinfelder

Ground Water Flow Modeling

Kleinfelder calculated the discharge of ground water to surface water within the Class III-B overburden area shown in **Figure 1**. The Class III-B overburden area is consistent with the area previously defined (Dan Raviv Associates, Inc., 2000) and approved by NJDEP (NJDEP, 2002).

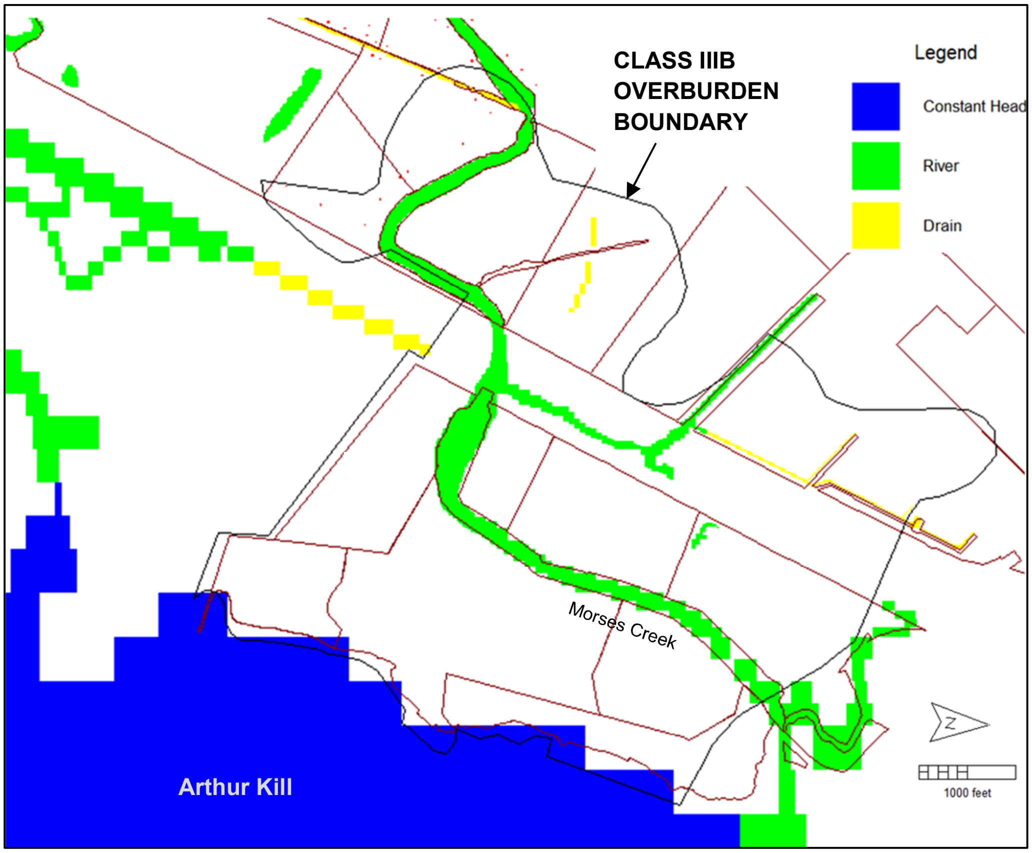

Figure 1: The black outline shows the Class III-B Overburden Area. Model boundary conditions are defined in the Legend.

For this purpose, the Regional Ground Water Flow Model (updated in the 1st quarter of 2022) was utilized. The Hydrostratigraphy package in Groundwater Vistas Version 8.11 was used to delineate the eight Sectors (**Figure 2**). A particle tracking engine (MODPATH) was used to assess and evaluate ground water movement patterns, flow paths, and travel directions from the Sectors in the advective flow model. The ground water discharge to surface water from each Sector was estimated from both Layer 1 (alluvium / fill) and Layer 2 (glacial till) in the Regional Model.

© 2022 Kleinfelder

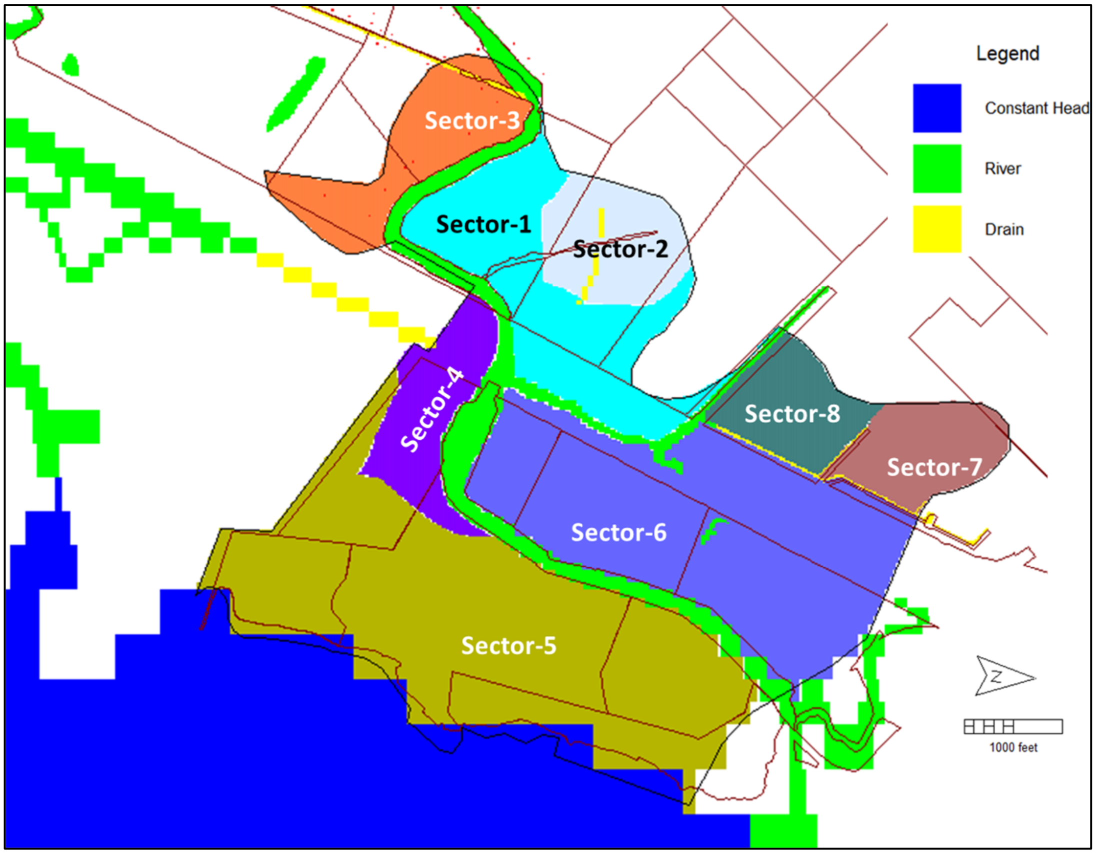

Figure 2: Sectors within the Class III-B area that contribute ground water to surface water.

Table 1 (attached) summarizes the relationships between ground water flow sectors and IAOCs. The components of modeled outflows were tabulated to calculate total discharge values from each Sector. As shown in **Table 2** (attached), the total ground water discharged from the eight Sectors is approximately 0.11 million gallons per day. This is comparable to the total ground water discharge value of 0.14 million gallons per day presented in the May 2001, *Proposed Alternative Site-Specific Ground Water Quality Criteria for the Class III-B Area.* The observed differences reflect additional site assessment information collected since 2001, and improved site understanding based on the operation of various ground water recovery systems over the last 20 years.

Identification of Constituents of Concern

COCs for which Class III-B criteria could be developed were determined through a two-step process. First, a review of the last ten years of ground water sample analytical data was performed for samples collected from the applicable IAOCs. Any analyte whose detected concentration was greater than the Class II-A Ground Water Criteria (N.J.A.C. 7:9C *et seq.*) was assigned to an applicable flow sector and retained for additional evaluation. **Table 3** (attached) summarizes these analytes on a sector basis.

© 2022 Kleinfelder

For consistency purposes, the COCs with calculated 2002 Class III-B Ground Water Quality Criteria were also included (even if they did not exceed the Class II-A Ground Water Criteria as defined above).

Second, the availability of either existing NJ Surface Water Criteria (or a Region 4 Screening Values) was determined, as summarized in **Table 4**. If an analyte had a NJ Surface Water Criteria based on ecological risk (for instance lead) then the NJ Criteria was used. If the NJ Surface Water Criteria was based on human health pathways, the Region 4 Screening Value was used. If no NJ Criteria was available, the Region 4 Screening Value was used. If neither a NJ Surface Water Criteria, nor a Region 4 Screening Value was available, no Class III-B alternative criteria are currently proposed.

Attenuation Factor Determination

Following the methodology previously used and approved (NJDEP, 2002) for determination of the attenuation factor, the ground water flow model was evaluated to determine which flow sector has the greatest contribution of ground water compared to surface water flows under the undeveloped (no refinery) scenario. As in 2002, Sector 1 (0.027 million gallons per day (MGD)) and Sector 6 (0.028 MGD) has the least dilution into the estimated surface water flow of approximately 1 MGD. The calculated attenuation factor is therefore 0.028 (unitless). Conservatively assuming that no impacts to Morses Creek occur due to operations upstream of the Sector 1 location under an undeveloped scenario, potential impacts to the surface water body may be estimated as the concentration in groundwater times the attenuation factor.

Class III-B Ground Water Criteria Calculation

For simplicity, the attenuation factor of 0.028 (the least expected attenuation) is used for all COCs. Determination of a concentration in ground which is not anticipated to exceed an available surface water criteria (NJ Surface Water Quality Standard or Region 4 Screening Value) can be accomplished by dividing the surface water criteria by the attenuation factor. A summary of the Proposed Class III-B criteria is included in **Table 5** (attached).

Due to changes in NJ Surface Water Criteria and/or the underlying parameters used in criteria development since 2001, as well as refinements in the ground water flow model, the previously approved Class III-B Ground Water Quality Criteria have changed. Once approved by the NJDEP, these new proposed criteria will take place of the 2002 Class III-B Criteria.

Conclusions and Recommendations

Proposed Class III-B Ground Water Criteria have been developed for COCs in the overburden ground water within the Class III-B area previously delineated. Mike Renzulli, LSRP for the ExxonMobil environmental investigation at the Bayway Refinery Complex, has reviewed and approved the proposed criteria. Based on the above information, ExxonMobil requests the NJDEP's concurrence with the LSRP's approval. If you have questions or would like to discuss further, please contact the undersigned.

© 2022 Kleinfelder

Respectfully,
KLEINFELDER

Paul C. Lucuski, P.E.
Project Manager

Nathan Stevens, PG (ME & NH)
Hydrogeologist

Limitations

Kleinfelder performed the services for this project under the Enabling Agreement with Procurement, a division of ExxonMobil Global Services Company (signed on November 28, 2012). Kleinfelder states that the services performed are consistent with professional standard of care defined as that level of services provided by similar professionals under like circumstances. This report is based on the regulatory standards in effect on the date of the report. It has been produced for the primary benefit of ExxonMobil Global Services Company and its affiliates.

References

Barringer, J. R. (2013). *Arsenic in New Jersey Coastal Plain streams, sediments, and shallow groundwater: effects from different geologic sources and anthropogenic inputs on biogeochemical and physical mobilization processes (No. 2013-5107).* Washington, D.C.: United States Geological Survey.

Cozzarelli, I. M. (2016). Arsenic cycling in hydrocarbon plumes: secondary effects of natural attenuation. *Groundwater*, 35-45.

Czarnik, T., & Kozinski, J. (1994). *Ground-water Qaulity in the Central Part of the Passaic River Basin, Northeastern New Jersey 1959-88 WRIR 92-4083.* Washington, D.C.: United States Geological Survey.

Dan Raviv Associates, Inc. (2000). *Verification of Class III-B Ground Waters Bayway Refinery Linden, New Jersey.* Millburn, NJ: Dan Raviv Associates, Inc.

Geraghty & Miller, Inc. (1993). *Site History Report.* Rochelle Park, NJ: Geraghty & Miller, Inc.

Geraghty & Miller, Inc. (1993). *Site History Report Volume I & II, Bayway Refinery, Linden, NJ.* Rochelle Park, NJ: Geraghty & Miller, Inc.

Kleinfelder, Inc. . (2021, 10 21). Email from Paul Lucuski to Charles Zielinski (NJDEP). ExxonMobil Bayway - Proposed Surface Water Quality Standards. .

© 2022 Kleinfelder

NJDEP. (2002, 12 13). In the Matter of ExxonMobil Bayway Refinery, ISRA Case Nos. 92726 & 94703 November 27, 1991 Administrative COnsent Order (ACO), Amended 4/8/93 and 12/22/94 Class III-B Ground Water Reclassification and Class III-B Ground Water Quality Criteria. Trenton, NJ.

TRC. (2016). *Site-Wide Bedrock Ground Water Pre-Design Investigation Report.* New Providence, NJ: TRC Environmental Corporation.

TRC Raviv. (2004). *Bayway Refinery Phase 2 Remedial Investigation Report.* Millburn, NJ: TRC Raviv Associates, Inc.

US EPA. (2018). *Region 4 Ecological Risk Assessment Supplemental Guidance.* Atlanta, GA, USA: United States Environmental Protection Agency Region 4 Superfund Division's Scientific Support Section.

Attachments

© 2022 Kleinfelder

TABLES

Table 1
Investigative Areas of Concern and Ground Water Flow Sectors
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Groundwater Flow Sector	A7a	A7b	A16	A17	A18	B1	B2	B3	C1	C2	C3	C4	C5	E2	E3	E4
Sector 1			X	X	X											
Sector 2			X	X	X											
Sector 3														X	X	X
Sector 4									X		X					
Sector 5									X	X	X	X	X			
Sector 6						X	X	X								
Sector 7	X	X														
Sector 8	X															

Table 2
Ground Water Flow Sectors
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Groundwater Flow Sector	Water Dicharge From Layers 1 & 2 (cubic feet per day)	Water Dicharge From Layers 1 & 2 (million gallons per day)
Sector 1	3,650	0.027
Sector 2	1,440	0.011
Sector 3	853	0.006
Sector 4	524	0.004
Sector 5	1,049	0.008
Sector 6	3,706	0.028
Sector 7	1,812	0.014
Sector 8	1,748	0.013
Total	14,782	0.11

Table 3
Contaminants of Concern and Ground Water Flow Sectors
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Groundwater Flow Sector	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
1,1,1-trichloroethane					X			
1,1,2,2-tetrachloroethane	X	X		X	X	X	X	X
1,1,2-trichloroethane	X	X		X	X	X	X	X
1,1-dichloroethane					X			X
1,1-dichloroethylene	X	X		X		X	X	
1,2,4-trichlorobenzene	X	X		X	X	X	X	X
1,2-dibromo-3-chloropropane	X	X	X	X	X	X	X	X
1,2-dibromoethane	X	X		X	X	X	X	X
1,2-dichloroethane	X	X	X	X	X	X	X	X
1,2-dichloropropane	X	X		X	X	X	X	X
1,4-dichlorobenzene					X			
1,4-Dioxane	X	X	X	X	X	X	X	X
1-Methylnaphthalene			X	X	X			
2,4-dichlorophenol					X			
2,4-dimethylphenol	X	X		X	X		X	X
2,4-dinitrophenol	X	X			X		X	X
2,4-dinitrotoluene					X			
2,6-dinitrotoluene					X			
2-butanone					X		X	X
2-hexanone	X	X			X		X	X
2-Methylnaphthalene	X	X			X			
2-Methylphenol	X	X		X	X			
3,3-dichlorobenzidine					X		X	X
4,6-dinitro-2-methylphenol	X	X		X	X	X	X	X
4-chloroaniline					X		X	X
Aluminum	X	X	X	X	X	X	X	X
Antimony	X	X	X	X	X	X	X	X
Arsenic	X	X	X	X	X	X	X	X
Atrazine	X	X			X		X	X
Barium					X		X	
Benzene	X	X		X	X	X	X	X
Benzo[a]anthracene	X	X	X	X	X	X	X	X
Benzo[a]pyrene	X	X	X	X	X	X	X	X
Benzo[b]fluoranthene	X	X	X	X	X	X	X	X
Benzo[k]fluoranthene	X	X	X		X			
Beryllium	X	X	X	X	X	X	X	X
Bis(2-chloroethyl) ether					X		X	X
Bis(2-ethylhexyl) phthalate	X	X		X	X	X	X	X
Bromodichloromethane	X	X		X	X	X	X	X
Bromoform	X	X		X	X	X	X	X
Bromomethane	X	X		X	X	X	X	X
Cadmium	X	X	X	X	X	X	X	X
Carbon tetrachloride	X	X		X	X	X	X	X
Chlorobenzene					X			
Chloroethane	X	X		X	X	X	X	X
Chloroform				X	X			
Chloromethane					X			
Chromium III	X	X	X	X	X	X	X	X
Chrysene	X	X	X		X			

Table 3
Contaminants of Concern and Ground Water Flow Sectors
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Groundwater Flow Sector	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
cis -1,2 dichloroethylene					X			
cis -1,3 dichloropropene	X	X		X	X	X	X	X
Cobalt	X	X	X	X	X	X	X	X
Copper			X					
Dibenz[a,h]anthracene	X	X	X		X			
Dibromochloromethane	X	X		X	X	X	X	X
Di-n-octyl phthalate					X			
Hexachlorobenzene	X	X	X	X	X	X	X	X
Hexachlorobutadiene	X	X			X		X	X
Hexachlorocyclopentadiene					X		X	X
Hexachloroethane					X		X	X
Indeno[1,2,3-c,d]pyrene	X	X	X		X	X	X	X
Iron	X	X	X	X	X	X	X	X
Isophorone							X	X
Lead	X	X	X	X	X	X	X	X
Manganese	X	X	X		X	X	X	X
Mercury	X	X	X	X	X			
Methyl *tert* -butyl ether					X			
Methylene chloride	X	X		X	X	X		X
Nickel	X	X	X	X	X	X		X
Nitrobenzene	X	X			X			
n-nitrosodi-n-propylamine					X			
n-nitrosodiphenylamine					X			
Pentachlorophenol	X	X		X	X	X	X	
Phenanthrene	X	X						
Selenium	X	X		X	X	X	X	X
Silver						X	X	X
Sodium	X	X	X	X	X	X	X	X
tert- butyl alcohol	X	X	X	X	X	X	X	X
Tetrachloroethylene	X	X		X	X	X	X	X
Thallium	X	X	X	X	X	X	X	X
trans -1,3 dichloropropene	X	X		X	X	X	X	X
Trichloroethylene	X	X	X	X	X	X	X	X
Vinyl chloride	X	X	X	X	X	X	X	X
Zinc	X	X	X	X	X	X	X	X

Table 4 Surface Water Quality Criteria
Used in Calculating Alternative Site-Specific Class III-B Ground Water Quality Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

		Saline Water	
Chemical	Units	NJDEP Saline Water (SE & SC) Criteria – Chronic	US EPA Region 4 Saline Surface Water Screening Values – Chronic
BW_Metals_complete			
Antimony	µg/L	~	4300
Arsenic	µg/L	36	36
Barium	µg/L	~	4
Beryllium	µg/L	~	0.13
Cadmium	µg/L	8.8	7.9
Calcium	µg/L	~	~
Chromium	µg/L	~	~
Chromium III	µg/L	~	~
Chromium VI	µg/L	50	~
Cobalt	µg/L	~	~
Copper	µg/L	3.1 (5.6 for AK)	3.1
Iron	µg/L	~	300
Lead	µg/L	24	8.1
Magnesium	µg/L	~	~
Manganese	µg/L	~	100
Mercury	µg/L	0.94	0.94
Nickel	µg/L	22	8.2
Potassium	µg/L	~	~
Selenium	µg/L	71	71
Silver	µg/L	~	0.1
Sodium	µg/L	~	~
Thallium	µg/L	~	6.3
Vanadium	µg/L	~	~
Zinc	µg/L	81	81
Aluminum	µg/L	~	1500
BW_SVOC_COMPLETE			
1,1'-Biphenyl	µg/L	~	49
1,2,4,5-Tetrachlorobenzene	µg/L	~	6
1,4-dichlorobenzene	µg/L	~	115
1,4-Dioxane	µg/L	~	200733
2,3,4,6-Tetrachlorophenol	µg/L	~	32
2,4,5-trichlorophenol	µg/L	~	12
2,4,6-trichlorophenol	µg/L	~	6.5
2,4-dichlorophenol	µg/L	~	790
2,4-dimethylphenol	µg/L	~	193
2,4-dinitrophenol	µg/L	~	14
2,4-dinitrotoluene	µg/L	~	9.1
2,6-dinitrotoluene	µg/L	~	36
2-chloronaphthalene	µg/L	~	~
2-chlorophenol	µg/L	~	400
2-Methylnaphthalene	µg/L	~	52
2-Methylphenol	µg/L	~	995
2-nitroaniline	µg/L	~	17

Table 4 Surface Water Quality Criteria
Used in Calculating Alternative Site-Specific Class III-B Ground Water Quality Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

		Saline Water	
		NJDEP Saline Water (SE & SC) Criteria – Chronic	US EPA Region 4 Saline Surface Water Screening Values – Chronic
Chemical	**Units**		
2-nitrophenol	µg/L	~	900
3,3-dichlorobenzidine	µg/L	~	13
3-nitroaniline	µg/L	~	~
4,6-dinitro-2-methylphenol	µg/L	~	~
4-bromophenyl phenyl ether	µg/L	~	2
4-chloro-3-methylphenol	µg/L	~	241
4-chloroaniline	µg/L	~	0.8
4-chlorophenyl phenyl ether	µg/L	~	~
4-Methylphenol	µg/L	~	405
4-nitroaniline	µg/L	~	~
4-nitrophenol	µg/L	~	600
Acenaphthene	µg/L	~	15
Acenaphthylene	µg/L	~	28
Acetophenone	µg/L	~	~
Anthracene	µg/L	~	0.43
Atrazine	µg/L	~	~
Benzaldehyde	µg/L	~	143
benzo[a]anthracene	µg/L	~	0.35
benzo[a]pyrene	µg/L	~	0.02
benzo[b]fluoranthene	µg/L	~	0.06
benzo[g,h,i]perylene	µg/L	~	0.012
benzo[k]fluoranthene	µg/L	~	0.06
Bis(2-chloro-1-methylethyl) ether	µg/L	~	~
bis(2-chloroethoxy) methane	µg/L	~	~
bis(2-chloroethyl) ether	µg/L	~	~
bis(2-ethylhexyl) phthalate	µg/L	~	6
butyl benzyl phthalate	µg/L	~	18
Caprolactam	µg/L	~	~
Carbazole	µg/L	~	112
Chrysene	µg/L	~	0.35
dibenz[a,h]anthracene	µg/L	~	0.01
Dibenzofuran	µg/L	~	61
diethyl phthalate	µg/L	~	59
dimethyl phthalate	µg/L	~	3295
di-n-butyl phthalate	µg/L	~	27
di-n-octyl phthalate	µg/L	~	215
Fluoranthene	µg/L	~	0.82
Fluorene	µg/L	~	24
hexachlorobenzene	µg/L	~	0.15
hexachlorobutadiene	µg/L	~	0.3
hexachlorocyclopentadiene	µg/L	~	0.07
hexachloroethane	µg/L	~	33

Table 4 Surface Water Quality Criteria
Used in Calculating Alternative Site-Specific Class III-B Ground Water Quality Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

		Saline Water	
		NJDEP Saline Water (SE & SC) Criteria – Chronic	**US EPA Region 4 Saline Surface Water Screening Values – Chronic**
Chemical	**Units**		
indeno[1,2,3-c,d]pyrene	µg/L	~	0.012
isophorone	µg/L	~	996
Naphthalene (extractable)	µg/L	~	1.4
nitrobenzene	µg/L	~	1046
n-nitrosodi-n-propylamine	µg/L	~	~
n-nitrosodiphenylamine	µg/L	~	48
Pentachlorophenol	µg/L	7.9	7.9
Phenanthrene	µg/L	~	4.6
phenol	µg/L	~	58
Pyrene	µg/L	~	0.11
Total TICs, Semi_volatile	µg/L	~	~
BW_VOC_COMPLETE			
1,1,1-Trichloroethane	µg/L	~	1560
1,1,2,2-Tetrachloroethane	µg/L	~	10.8
1,1,2-trichloro-1,2,2-trifluoroethane	µg/L	~	~
1,1,2-Trichloroethane	µg/L	~	2097
1,1-Dichloroethane	µg/L	~	2692
1,1-Dichloroethene	µg/L	~	3.2
1,2,3-trichlorobenzene	µg/L	~	5
1,2,4-trichlorobenzene	µg/L	~	5.4
1,2-dibromo-3-chloropropane	µg/L	~	~
1,2-dibromoethane	µg/L	~	~
1,2-Dichlorobenzene	µg/L	~	42
1,2-Dichloroethane	µg/L	~	5650
1,2-Dichloropropane	µg/L	~	1064
1,3-Dichlorobenzene	µg/L	~	390
1,4-Dichlorobenzene	µg/L	~	115
2-butanone	µg/L	~	65695
2-Hexanone	µg/L	~	16871
4-methyl-2-pentanone	µg/L	~	19142
Acetone	µg/L	~	117629
Benzene	µg/L	~	110

Table 4 Surface Water Quality Criteria
Used in Calculating Alternative Site-Specific Class III-B Ground Water Quality Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

		Saline Water	
		NJDEP Saline Water (SE & SC) Criteria – Chronic	US EPA Region 4 Saline Surface Water Screening Values – Chronic
Chemical	Units		
bromochloromethane	µg/L	~	~
Bromodichloromethane	µg/L	~	3510
Bromoform	µg/L	~	360
Bromomethane	µg/L	~	265
Carbon disulfide	µg/L	~	253
Carbon tetrachloride	µg/L	~	4.4
Chlorobenzene	µg/L	~	25
Chloroethane	µg/L	~	~
Chloroform	µg/L	~	471
Chloromethane	µg/L	~	~
cis-1,2-Dichloroethene	µg/L	~	1629
cis-1,3-Dichloropropene	µg/L	~	~
cyclohexane	µg/L	~	158
Dibromochloromethane	µg/L	~	34
Dichlorodifluoromethane	µg/L	~	~
Ethylbenzene	µg/L	~	25
isopropylbenzene	µg/L	~	98
m/p-xylene	µg/L	~	~
methyl acetate	µg/L	~	~
methyl cyclohexane	µg/L	~	52
Methyl Tertiary Butyl Ether	µg/L	18000	5000
Methylene chloride	µg/L	~	1580
o-xylene	µg/L	~	~
Styrene	µg/L	~	412
tert-Butyl alcohol	µg/L	~	~
Tetrachloroethene	µg/L	~	8.85
Toluene	µg/L	~	215
Total TICs	µg/L	~	~
trans-1,2-Dichloroethene	µg/L	~	1629
trans-1,3-Dichloropropene	µg/L	~	~
Trichloroethene	µg/L	~	81
Trichlorofluoromethane	µg/L	~	~
Vinyl chloride	µg/L	~	2276
xylenes, total	µg/L	~	260

Notes:

(yellow)	Proposed Bayway Surface Water Standard. Please note that not all metals/compounds lists above are contaminants of concern (COCs) at the Bayway Refinery Complex.
(orange)	Freshwater aquatic criteria for cadmium, chromium III, copper, nickel, silver, and zinc are expressed as a function of water

Table 5
Calculation of Alternative Site-Specific Class III-B Ground Water Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Compound of Concern	NJ DEP SWQS (µg/L)	2018 EPA R4 ERA SG SALT (µg/L)	Ground Water/Surface Water Flow Rate	Proposed Class III-B (µg/L)
1,1,1-trichloroethane	NA	1,560	0.028	55,714
1,1,2,2-tetrachloroethane	NA	10.8	0.028	386
1,1,2-trichloroethane	NA	2,097	0.028	74,893
1,1-dichloroethane	NA	2,692	0.028	96,143
1,1-dichloroethylene	NA	3.2	0.028	114
1,2,4-trichlorobenzene	NA	5.4	0.028	193
1,2-dibromo-3-chloropropane	NA	NA	0.028	None
1,2-dibromoethane	NA	NA	0.028	None
1,2-dichloroethane	NA	5,650	0.028	201,786
1,2-dichloropropane	NA	1,064	0.028	38,000
1,4-dichlorobenzene	NA	115	0.028	4,107
1,4-Dioxane	NA	200,733	0.028	7,169,036
2-Methylnaphthalene	NA	52	0.028	1,857
2,4-dichlorophenol	NA	790	0.028	28,214
2,4-dimethylphenol	NA	193	0.028	6,893
2,4-dinitrophenol	NA	14	0.028	500
2,4-dinitrotoluene	NA	9.1	0.028	325
2,6-dinitrotoluene	NA	36	0.028	1,286
2-butanone	NA	65,695	0.028	2,346,250
2-hexanone	NA	16,871	0.028	602,536
2-Methylnaphthalene	NA	52	0.028	1,857
2-Methylphenol	NA	995	0.028	35,536
3,3'-dichlorobenzidine	NA	13	0.028	464
4,6-dinitro-2-methylphenol	NA	NA	0.028	None
4-chloroaniline	NA	0.8	0.028	29
Acetone	NA	117,629	0.028	4,201,036
Aluminum	NA	1,500	0.028	53,571
Antimony	NA	4,300	0.028	153,571
Arsenic	36	36	0.028	1,286
Atrazine	NA	NA	0.028	None
Barium	NA	4	0.028	143
Benzene	NA	110	0.028	3,929
Benzo[a]anthracene	NA	0.35	0.028	13
Benzo[a]pyrene	NA	0.02	0.028	1
Benzo[b]fluoranthene	NA	0.06	0.028	2
Benzo[k]fluoranthene	NA	0.06	0.028	2
Beryllium	NA	0.13	0.028	5
Bis(2-chloroethyl) ether	NA	NA	0.028	None
Bis(2-ethylhexyl) phthalate	NA	6	0.028	214
Bromodichloromethane	NA	3,510	0.028	125,357
Bromoform	NA	360	0.028	12,857
Bromomethane	NA	265	0.028	9,464
Cadmium (filtered)	8.8	7.9	0.028	314
Carbon tetrachloride	2.3	4.4	0.028	82
Chlorobenzene	NA	25	0.028	893
Chloroethane	NA	NA	0.028	None
Chloroform	NA	471	0.028	16,821
Chloromethane	NA	NA	0.028	None
Chromium III (filtered)	Hardness Dependent	Hardness Dependent	0.028	None
Chrysene	NA	0.35	0.028	13
cis -1,2 dichloroethylene	NA	1,629	0.028	58,179
cis -1,3 dichloropropene	NA	NA	0.028	None
Cobalt	NA	NA	0.028	None

Table 5
Calculation of Alternative Site-Specific Class III-B Ground Water Criteria
Bayway Refinery Complex
1400 Park Avenue
Linden, NJ

Compound of Concern	NJ DEP SWQS (µg/L)	2018 EPA R4 ERA SG SALT (µg/L)	Ground Water/Surface Water Flow Rate	Proposed Class III-B (µg/L)
Copper (filtered)	5.6	3.1	0.028	200
Dibenz[a,h]anthracene	NA	0.01	0.028	0
Dibromochloromethane	NA	34	0.028	1,214
Di-n-octyl phthalate	NA	215	0.028	7,679
Hexachlorobenzene	NA	0.15	0.028	5
Hexachlorobutadiene	NA	0.3	0.028	11
Hexachlorocyclopentadiene	NA	0.07	0.028	3
Hexachloroethane	NA	33	0.028	1,179
Indeno[1,2,3-c,d]pyrene	NA	0.012	0.028	0
Iron	NA	300	0.028	10,714
Isophorone	NA	996	0.028	35,571
Lead (filtered)	24	8.1	0.028	857
Manganese	NA	100	0.028	3,571
Mercury	0.94	0.94	0.028	34
Methyl *tert*-butyl ether	18000	5,000	0.028	642,857
Methylene chloride	NA	1,580	0.028	56,429
Naphthalene	NA	1.4	0.028	50
Nickel (filtered)	22	8.2	0.028	786
Nitrobenzene	NA	1,046	0.028	37,357
n-nitrosodi-n-propylamine	NA	NA	0.028	None
n-nitrosodiphenylamine	NA	48	0.028	1,714
Phenol	NA	58	0.028	2,071
Pentachlorophenol	7.9	7.9	0.028	282
Phenanthrene	NA	4.6	0.028	164
Selenium (unfiltered)	71	71	0.028	2,536
Silver (filtered)	NA	0.1	0.028	4
Sodium	NA	NA	0.028	None
***tert*-butyl alcohol**	NA	NA	0.028	None
Tetrachloroethylene	NA	8.85	0.028	316
Thallium	NA	6.3	0.028	225
***trans*-1,3 dichloropropene**	NA	NA	0.028	None
Trichloroethylene	NA	81	0.028	2,893
Vinyl chloride	NA	2,276	0.028	81,286
Zinc (filtered)	81	81	0.028	2,893

Notes:

NJ DEP SWQC	Surface Water Quality Standard as promulgated in New Jersey Administrative Code 7:9B Saline Water Criteria for Chronic Aquatic Effects
2018 EPA R4 ERA SG SALT	United States Environmental Protection Agency Region 4 Saltwaer Screening Values for Chronic Aquatic Effects
NA	Not available